POLYGONAL IMPACT CRATERS AS AN INDICATOR OF FRACTURING - AN EXAMPLE FROM GREATER HELLAS REGION, MARS. T. Öhman[1], M. Aittola[2], V.-P. Kostama[2] & J. Raitala[2]. [1]Institute of Geosciences, Department of Geology, P.O. Box 3000, FIN-90014 University of Oulu, Finland, <teemu.ohman@oulu.fi>; [2]Astronomy, Department of Physical Sciences, P.O. Box 3000, FIN-90014 University of Oulu, Finland.

Introduction: Polygonal plan view is a long known [e.g. 1,2,3] but largely forgotten feature of impact craters. The aim of this study is to map the distribution of polygonal craters in the greater Hellas region, Mars, and to analyse whether or not polygonal craters can be used as a tool in the investigation of the structural and tectonic features of a planet's crust. One goal of this work is also to revive the concept of polygonal craters in the impact cratering community.

The origin of polygonal craters: A fractured target material is a pre-requisite for the formation of polygonal craters. Polygonal simple craters result when the excavation of the crater progresses more easily along a fracture (or some other plane of weakness) than in other directions [4]. This typically leads to a squarish outline, with crater rims making approximately an angle of 45° with the fracture directions [4,5]. However, experiments have shown that two perpendicular fracture directions can also lead to three rim orientations, i.e. a hexagonal crater [6]. Therefore the information gained from the study of small polygonal crater rims can not be unambiguously transferred to regional fracture directions.

Polygonal complex craters are the result of slumping in the modification stage of the cratering process: the collapse of the rim takes place along some plane of weakness in the target [4]. Thus, the dominant fracture directions in the area can be directly measured from the orientations of the straight rim segments in complex polygonal craters.

Methods: We have mapped the polygonal impact craters in the geologically diverse greater Hellas region (lat. 2°N-66°S, long. 8°W-208°W, Fig. 1) by using the Viking Orbiter Mars Digital Image Mosaic (MDIM). The resolution of the images is 0,231 km per pixel at the equator, but gets worse further south. The study area was divided into 40 blocks, each of which was examined independently by two researchers. We defined "polygonal crater" as being a crater with at least two straight rim segments and a clearly discernible angle between them. We disregarded craters where the polygonal outline was distinctively a result of post-impact processes.

The strikes of the rim directions were measured from three major parts of the study area: the highland area south from Isidis (reaching the volcanic plains of Elysium Planitia in the northeastern corner of our study area) including parts of Hesperia Planum, Hellespontus Montes west from Hellas and the volcanic plains of Malea Planum. In Malea Planum only polygonal craters formed in the plains material were included. The number of strike measurements in each block varies from 173 (southwest from Isidis) to only 16 (Malea Planum). The strikes were then plotted in rose diagrams using 10° azimuth intervals. The precision is estimated to be ±5°. Practically all polygonal craters were at least about 10 km in diameter and, thus, were the size of complex craters [7]. Therefore, the measured rim strikes are parallel to the fractures in the target [4].

Results: The vast majority of polygonal craters in greater Hellas region are, or have a tendency towards being hexagonal (Fig. 2). In addition, pentagons occur relatively often, but clearly square-shaped craters tend to be rare. Polygonal craters are most common in the northern part of the study area close to the Isidis impact basin (Fig. 1). Another major concentration of polygonal craters is in Hellespontus Montes. In the volcanic plains of Hesperia Planum and especially Malea Planum the number of polygonal craters is low. Worth noting is that the polygonal craters in Malea Planum are generally smaller and not as clearly polygonal as in other parts of the study area.

In Hellespontus Montes the rim strikes display strong E-W and N-S components (Fig. 3a). The former direction is radial to Hellas and latter coincides with grabens in the area. Immediately west from Hellespontus Montes the N-S component weakens while the E-W component is still prominent (Fig. 3b). In the southwestern side of Isidis the dominance of radial NE-SW trending rims is obvious (Fig. 4a). Similarly in the southeastern side of Isidis rims oriented radial to Isidis (NW-SE) are visible, although there is a lot more scatter in the rim strikes (Fig. 4b). Immediately to the south, partly on Hesperia Planum in the vicinity of Hadriaca and Tyrrhena Paterae, the rim strikes seem to reflect fracture systems radial to Hellas and Isidis, with an overprint from the paterae. In the southern part of Elysium Planitia the crater rim strikes are affected by Elysium Mons. The few polygonal craters in Malea Planum display varied rim orientations with no apparent contribution from Hellas.

Conclusions and further work: Crater rims reveal beautifully the development of radial fractures around Isidis impact basin. The dominance of hexagonal craters is manifested in some of the rose diagrams by rim strike peaks with intervals of about 60°. In Hellespontus Montes the radial fracturing caused by the Hellas impact basin is evident, but concentric fracturing is also present. In Hesperia Planum polygonal craters reflect distant fracturing radial to Hellas with later overprinting of volcanotectonic fracturing. Also distant Isidis-centered radial fracturing [8] gets support from our data. It appears that the basin-centered radial fracturing reaches further than concentric fracturing.

The method used in this study can be easily developed further. Instead of considering the abundance of polygonal craters, it would be more useful to study the ratio of polygonal and circular craters. Statistical analysis would be then used to determine the significance of the results. Also the effect of crater size should be studied in detail.

This work has shown that the direction distribution of the polygonal crater rims can be an effective and easily applicable tool in determining the fracture patterns and possibly some target material properties on cratered surfaces. Our method would be best used alongside with traditional means of mapping tectonic deformation. The abundance and universality of polygonal craters – we have observed them on all the terrestrial planets and several asteroids and moons – indicate that the effect of structural control should be incorporated to cratering models in order to produce realistic scenarios of the cratering process.

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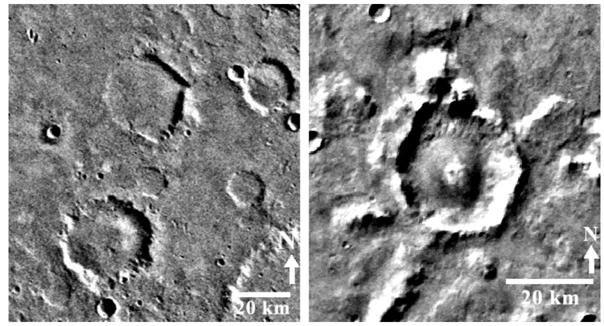
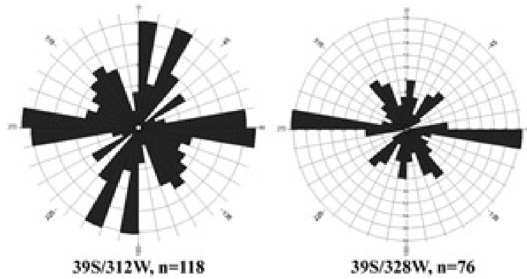
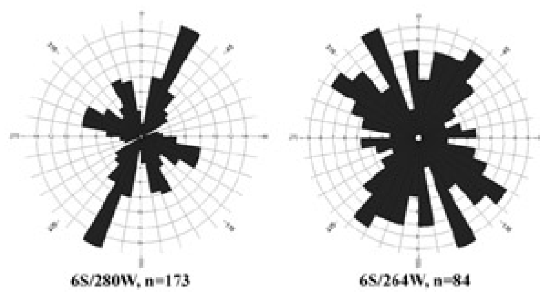


Figures 2a (25°S/277°W) and 2b (28°S/283°W). Hexagonal craters north from Hellas. Many of the rims in Fig. 2a are parallel to each other.



Figures 3a and 3b. Rose diagrams of crater rim strikes from Hellespontus Montes (30°S-48°S, 304°W-320°W) and west from Hellespontus Montes (30°S-48°S, 320°W-336°W).



Figures 4a and 4b. Rose diagrams of crater rim strikes southwest from Isidis (2°N-14°S, 272°W-288°W) and southeast from Isidis (2°N-14°S, 256°W-272°W).

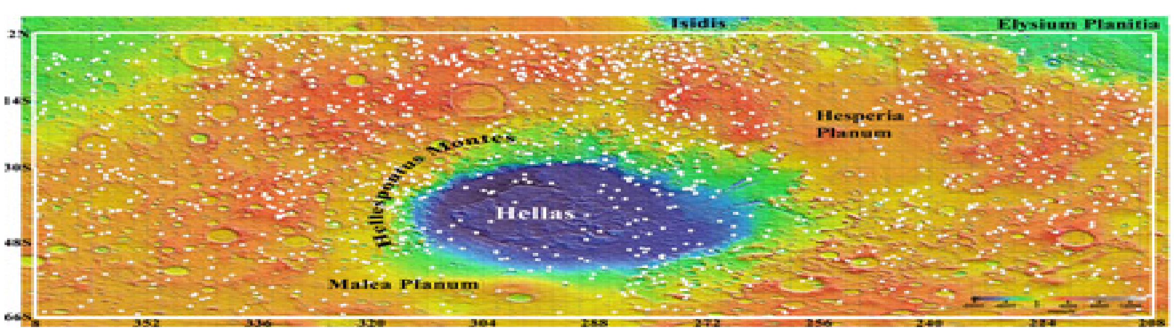


Figure 1. The distribution of polygonal craters (dots) in greater Hellas region plotted on MGS-MOLA data.